CLAIMS

What is Claimed is:

Sub A2

1. A method for noninvasively determining the concentration of a blood constituent comprising the steps of:

providing a tissue probe having a first radiation emitter with a first wavelength and a first radiation detector configured to receive the first wavelength after absorbance through a radiation path length of the patient's blood;

measuring absorbance of the patient's blood by emitting radiation at the first wavelength through the patient's blood and detecting the radiation after passage through the patient's blood;

varying the volume of blood to change the path length of the probe to provide multiples of path length;

measuring absorbance of the patient's blood at each multiple of the path length; and

determining the concentration of the blood constituent based upon the changing absorbance.

2. The method of claim 1, wherein the blood constituent comprises hemoglobin.

3. The method of claim 1, wherein the blood is venous blood.

4. The method of claim 1, wherein the blood is arterial blood.

5. The method of claim 1, further comprising the step of:

verifying the determination of concentration by comparing the radiation path length multiplied by the determined concentration to the measured absorbance.

6. The method of claim 1, wherein the step of providing a tissue probe comprises providing a tissue probe having a first and second radiation emitter with a first and second wavelength and a first and second radiation detector configured to receive the first and second wavelengths, respectively, after absorbance through a radiation path length of the blood and wherein the step of measuring the absorbance comprises measuring the absorbance at the first and second wavelengths.

7. A method for noninvasively determining physiologic parameters of a patient comprising the steps of:

providing a first tissue probe having a first radiation emitter with a first wavelength and a first radiation detector configured to receive the first wavelength after absorbance through a radiation path length of the patient's blood;

measuring absorbance of the patient's blood by emitting radiation at the first wavelength through the patient's blood and detecting the radiation after passage through the patient's blood;

providing a second tissue probe having a second radiation emitter with a second wavelength and a second radiation detector configured to receive the second wavelength after absorbance through a radiation path length;

measuring absorbance at the first and second probes;

performing a determination of hemoglobin absorbance at the first and second probes;

timing the arrival of pulse and flow waves at the first and second probes by comparing the hemoglobin absorbance at the first and second probes; and

determining a cardiac characteristic based upon the arrival of the pulse and flow waves at the first and second probes.

8. A method for noninvasively determining the concentration of a blood constituent of a patient comprising the steps of:

providing a first and second tissue probe each having a first radiation emitter with a first wavelength and a first radiation detector configured to receive the first wavelength after absorbance through a first path length of the patient's blood at a first position relative to the heart of the patient;

measuring absorbance of the patient's blood by emitting radiation at the first wavelength through the patient's blood and detecting the radiation after passage through a first path length of the patient's blood;

varying the volume and pressure of the blood within the first and second probes;

measuring absorbance of the blood as the volume and pressure are varied; and;

computing the concentration of the blood constituent based on the absorbance at the varying pressures.

9. The method of claim 8, wherein the step of varying the pressure of the blood comprises changing the position of the probes relative to the patient's heart.

10. The method of claim 9, wherein the step of computing the concentration comprises calculating the distance the probes have moved relative to the patient's heart.

11. The method of claim 8, wherein the blood constituent comprises hemoglobin.

12. The method of claim 8, wherein the blood is venous blood.

13. The method of claim 8, wherein the blood is arterial blood.

14. The method of claim 8, further comprising the step of:

verifying the determination of concentration by comparing the first path length multiplied by the determined concentration to the measured absorbance.

15. The method of claim 8, further comprising the step of changing the path length of the first and second probes.

16. The method of claim 8, wherein the step of providing a first and second tissue probe comprises providing a first and second tissue probe each having a first and second radiation emitter with a first and second wavelength and a first and second radiation detector configured to receive the first and second wavelengths, respectively, after absorbance through a first path length of the blood and wherein the step of measuring the absorbance comprises measuring the absorbance at the first and second wavelengths.

17. A method for noninvasively determining physiologic parameters of a patient comprising the steps of:

providing a first and second tissue probe each having a first radiation emitter with a first wavelength and a first radiation detector configured to receive the first wavelength after absorbance through a radiation path length of the patient's blood at a first position relative to the heart of the patient;

measuring absorbance of the patient's blood by emitting radiation at the first wavelength through the patient's blood and detecting the radiation after passage through the radiation path length of the patient's blood;

varying the volume and pressure of the blood within the first and second probes;

measuring absorbance of the blood as the volume and pressure are varied;

timing the arrival of pulse and flow waves at the first and second probe by comparing the hemoglobin absorbance at the first and second probe; and

determining a cardiac characteristic based upon the arrival of the pulse and flow waves at the first and second probes at the varying pressures.

18. The method of claim 17, further comprising the step of using an electrocardiogram to correlate timing of the absorbance measurements.

19. A method for noninvasively determining the pH of blood of a patient comprising the steps of:

providing a first tissue probe having a first and second radiation emitter with a first and second wavelength, respectively, and a first and second radiation detector configured to receive the first and second wavelength, respectively, after absorbance through the patient's blood, wherein the absorbance of the first wavelength depends upon the pH of the blood and wherein the absorbance of the second wavelength is substantially independent of the pH of the blood;

measuring absorbance of the patient's blood by emitting radiation at the first and second wavelength through the patient's blood and detecting the radiation after passage through the patient's blood; and

computing the pH of the blood based upon the measured absorbance at the first and second wavelengths.

20. The method of claim 19, wherein the first and second wavelengths are chosen based upon the absorbance of species of hemoglobin.

21. The method of claim 20, wherein the species of hemoglobin are selected from the group consisting of methemoglobin, oxyhemoglobin, deoxyhemoglobin, and carboxyhemoglobin.

22. The method of claim 20, wherein the first wavelength is selected from the group consisting of about 535 nm, about 577 nm and about 600 nm and the second wavelength comprises a near infrared wavelength.

23. The method of claim 19, further comprising the step of varying the blood temperature.

24. The method of claim 19, further comprising the steps of:

providing a second tissue probe having a first and second radiation emitter with a first and second wavelength, respectively, and a first and second radiation detector configured to receive the first and second wavelength, respectively, after absorbance through the patient's blood, wherein the absorbance of the first wavelength depends upon

the pH of the blood and wherein the absorbance of the second wavelength is substantially independent of the pH of the blood;

measuring absorbance of the patient's blood at the first and second probe;

computing the pH of the blood based upon the measured absorbance at the first and second wavelengths at the first and second probes; and

determining the temperature of the blood based upon the computed pH.

25. The method of claim 24, wherein the first probe measures absorbance of venous blood and the second probe measures absorbance of arterial blood.

26. A method for non-invasively determining the concentration of a blood constituent comprising the steps of:

measuring absorbance of arterial and venous blood;

determining arterial and venous oxygen saturation;

subtracting hemoglobin absorbance based upon the arterial and venous saturation; and

determining the concentration of a blood constituent based upon remaining absorbance.

27. The method of claim 26, wherein the blood constituent comprises glucose.

28. The method of claim 27, further comprising the steps of measuring absorbance at a plurality of wavelengths and comparing arterial and venous absorbance at each wavelength.

29. A method for non-invasively determining a chemical analyte in a patient's blood comprising the steps of:

providing a tissue probe comprising a film containing a known concentration of the analyte;

measuring absorbance of the film and tissue of the patient;

changing the blood volume of the patient's tissue by raising or lowering the tissue relative to the patient's heart; and

comparing tissue absorbance to film absorbance to determine the relative concentration of the analyte in the patient's tissue to that in the film.

30. A method for non-invasively determining a cardiac characteristic of a patient comprising the steps of:

measuring pulse wave velocity in a first extremity;

determining flow wave velocity; and

computing the cardiac output characteristic using the flow wave velocity.

31. The method of claim 30, wherein the step of computing the cardiac characteristic comprises determining a characteristic selected from the group comprising cardiac output, cardiac index, cardiac stroke volume, cardiac ejection fraction, and blood volume.

32. The method of claim 30, further comprising the step of measuring pulse wave velocity in a second, opposite extremity and wherein the step of determining flow wave velocity comprises computing the flow wave velocity using the ratios of the pulse wave velocities in the first and second extremities.

33. The method of claim 32, wherein the first and second extremities comprise the patient's hands.

34. The method of claim 32, wherein the steps of measuring pulse wave velocity comprise measuring the time intervals for arrival of pulses in the first and second extremities.

35. The method of claim 30, further comprises the step of measuring blood pressure and wherein the step of determining flow wave velocity comprises computing the flow wave velocity using the blood pressure and the pulse wave velocity.

36. The method of claim 32, wherein the steps of measuring pulse wave velocity comprises the steps of placing tissue probes on different locations of the patient's body, continuously monitoring oxygen saturation in the patient's blood through the tissue probes, inducing a change in oxygen saturation, and comparing the arrival time of the saturation change at the tissue probes.

37. The method of claim 36, wherein the step of inducing a change in oxygen saturation comprises having the patient breath-hold.

38. The method of claim 30, further comprising the step of inducing a change in oxygen saturation.

39. The method of claim 38, wherein the cardiac characteristic is selected from the group comprising cardiac index, cardiac stroke volume and cardiac output, and the cardiac characteristic is computed by determining the time interval between the inducement of change in oxygen saturation and a first measured change in oxygen saturation.

40. The method of claim 38, wherein the cardiac characteristic comprises cardiac ejection fraction and the cardiac characteristic is computed by determining the time interval between a first measured change in oxygen saturation and maximal change in oxygen saturation.

41. The method of claim 38, wherein the cardiac characteristic comprises blood volume and the cardiac characteristic is computed by determining the time interval between the inducement of change in oxygen saturation and return to a baseline measured oxygen saturation.

42. The method of claim 36, wherein the step of inducing a change in oxygen saturation comprises providing an enriched oxygen atmosphere.

43. A method for noninvasively determining the blood pressure of a patient comprising the steps of:

measuring the pulse wave velocity in a first extremity of the patient at a first pressure;

inducing pressure change in the first extremity;

measuring the pulse wave velocity in the first extremity at a second pressure; and

computing the blood pressure using ratios of the pulse wave velocities and the hydrostatic pressure difference of the first and second pressures.

44. The method of claim 43, wherein the step of inducing pressure change in the extremity comrpises varying the height of the extremity relative to the patient's heart.

45. The method of claim 43, further comprising the step of measuring pulse wave velocity in a second extremity.

46. The method of claim 45, further comprising the step of inducing pressure change in the second extremity.

47. A method for noninvasively determining the blood pressure of a patient comprising the steps of:

measuring the time interval for a pulse to reach a given point in a first extremity at a first pressure

inducing pressure change in the extremity by varying the height of the first extremity relative to the patient's heart;

measuring the time interval for a pulse to reach the given point in the first extremity at a second pressure; and

computing the blood pressure using the ratios of the time intervals and the hydrostatic pressure difference of the first and second pressures.

48. The method of claim 47, further comprising the step of measuring the time interval for a pulse to reach a given point in a second extremity.

49. The method of claim 48, further comprising the step of inducing pressure change in the second extremity.

50. A method for noninvasively determining a patient's blood pressure comprising the steps of:

measuring pulse wave velocities in two opposite extremities; and

computing the blood pressure using the ratios of the pulse wave velocities.

51. A method for noninvasively determining the blood pressure comprising the steps of:

measuring the time intervals for arrival of a pulse in two opposite extremities; and

computing the blood pressure using the ratios of the two time intervals.

52. A method for noninvasively determining a patient's central venous pressure comprising the steps of:

elevating an extremity to a first position relative to the patient's heart;

continually measuring light absorbance in the extremity;

lowering the extremity to a second position relative to the patient's heart, wherein the second position comprises a position where light absorbance in the extremity increases with respect to light absorbance at the first position; and

computing central venous pressure using the hydrostatic pressure difference between the first position and the second position.

53. A method for noninvasively determining the concentration of a blood constituent comprising the steps of:

providing a tissue probe having a first radiation emitter with a first wavelength and a first radiation detector configured to receive the first wavelength after absorbance through a first path length of the patient's blood;

measuring absorbance of the patient's blood by emitting radiation at the first wavelength through the patient's blood and detecting the radiation after passage through the patient's blood;

calculating absorbance of the patient's blood at multiples of the path length; and

determining the concentration of the blood constituent based upon the changing absorbance.

54. A method for noninvasively determining the concentration of a blood constituent comprising the steps of:

providing a tissue probe having a first radiation emitter with a first wavelength and a first radiation detector configured to receive the first wavelength after absorbance through the patient's blood;

measuring absorbance of the patient's blood by emitting radiation at the first wavelength through the patient's blood and detecting the radiation after passage through the patient's blood;

varying the saturation of the blood;

measuring absorbance of the patient's blood at the varied saturation; and

determining the concentration of the blood constituent based upon the absorbance at the varied saturations.

55. A method for noninvasively determining the concentration of a blood constituent comprising the steps of:

providing a tissue probe having a first radiation emitter and a first radiation detector configured to receive radiation after absorbance through the patient's blood;

measuring absorbance of the patient's blood by emitting radiation at a first wavelength through the patient's blood and detecting the radiation after passage through the patient's blood;

measuring absorbance of the patient's blood by emitting radiation at a second wavelength through the patient's blood and detecting the radiation after passage through the patient's blood; and

determining the concentration of the blood constituent based upon the absorbance at the first and second wavelengths.

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